

## **CA-GREET Model**

### **Renewable diesel and renewable gasoline from tree residues**

### **Ensyn Corporation, Tesoro Corporation and Chevron Corporation**

The applicant has conducted its analysis of the carbon intensities of renewable diesel and gasoline via pyrolysis of tree residues using CA-GREET 2.0 (<http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm>). The standard inputs and parameters specified in CA-GREET remain unchanged except as noted by the applicant which is confidential information. The cells where the applicant modified the GREET default values are show below in Table 1-4. The relevant worksheet in the model is “Pyrolysis”. Co-processing of bio-oil to diesel and gasoline is based on the GREET default values for CA-refinery to arrive at the conservative refinery estimates.

**Table1 : GREET Summary – RG with Bio-oil Transport via Rail**

<b>Parameter</b>	<b>Sheet and Cell</b>	<b>Default Value</b>	<b>Modified Value</b>
Distance from mill to RFO production facility	T&D BX149	75	Confidential
Tree residue cargo capacity of HHD Truck	T&D AE7	18	Confidential
HHD Truck Energy consumption – backhaul	T&D CB165	969	Confidential
Diesel consumption for Tree Residue collection at mill, and receiving at RFO production facility	Inputs F275	118,006	Confidential
Tree Residue Shares (by dry weight)	Inputs F276	50%	Confidential
Moisture content of biomass when being transported	Inputs F465	30%	Confidential
Pyrolysis scenario selection	Inputs W607	Internal H2 from Fuel Gas/NG Reforming	Confidential
Biomass use (production of RFO)	Inputs Z610	3.19	Confidential
Energy use (production of RFO)	Inputs Z611	5,803	Confidential
Process Fuel Share – Electricity (production of RFO)	Inputs Z613	12.7%	Confidential
Process Fuel Share – Natural Gas (production of	Inputs Z614	0%	Confidential

RFO)			
Process Fuel Share – Hydrogen (production of RFO)	Inputs Z615	87.3%	Confidential
Co-products in Pyrolysis and Upgrading before Generation – Fuel Gas (production of RFO)	Inputs Z622	4201	Confidential
% of Carbon Sequestered by Bio-Char	Pyrolysis B75	80%	Confidential
Energy Content (RFO)	Pyrolysis E93	17,450	Confidential
Pyrolysis and Upgrading: Non-combustion Emissions (SMR)	Pyrolysis AM208:AM212 and BC208:BC212	0.54 2.67 0.00 0.00 3383.73	Confidential
Shares of Combustion Processes for Each Stage - Natural Gas Small Industrial Boiler	Pyrolysis J112	0%	Confidential
Transportation & Distribution of Renewable Gasoline – Energy Use	Pyrolysis AK136:AK140	Linked to Renewable Gasoline T&D (columns DK and DL in T&D)	Confidential
Transportation & Distribution of Renewable Gasoline – Emissions	Pyrolysis AK142:AK150	Linked to Renewable Gasoline T&D (columns DK and DL in T&D)	Confidential
Refinery Coprocessing in Conventional Refinery – Energy Use	Pyrolysis AJ136:AJ140	Default linking to Petroleum and Inputs tabs	Confidential
Refinery Coprocessing in Conventional Refinery – Emissions	Pyrolysis AJ142:AJ150	Default linking to Petroleum and Inputs tabs	Confidential
Rail Transport Distance – RFO to Refinery	T&D CA149	300	Confidential
Truck Transport Distance – RFO to Refinery	T&D CB149	50	Confidential
Select Feedstock	T2 Calculator B6	Miscanthus	Confidential
Select Fuel Pathway	T2 Calculator C6	Ethanol	Confidential
Select Tier 2 Fuels	T2 Calculator E7:F7	User-Defined Fuel Pathway	Confidential
Regional Electricity Mix for Feedstock	T2 Calculator B9	1-US Ave Mix	Confidential
Regional Electricity Mix for Fuel	T2 Calculator E9	1-US Ave Mix	Confidential
User-defined Electricity Mix	T2 Calculator R9:R17		Confidential

**Table 2: GREET Summary – RG with Bio-oil Transport via Truck**

Parameter	Sheet and Cell	Default Value	Modified Value
Distance from mill to RFO production facility	T&D BX149	75	Confidential
Tree residue cargo capacity of HHD Truck	T&D AE7	18	Confidential
HHD Truck Energy consumption – backhaul	T&D CB165	969	Confidential
Diesel consumption for Tree Residue collection at mill, and receiving at RFO production facility	Inputs F275	118,006	Confidential
Tree Residue Shares (by dry weight)	Inputs F276	50%	Confidential
Moisture content of biomass when being transported	Inputs F465	30%	Confidential
Pyrolysis scenario selection	Inputs W607	Internal H2 from Fuel Gas/NG Reforming	Confidential
Biomass use (production of RFO)	Inputs Z610	3.19	Confidential
Energy use (production of RFO)	Inputs Z611	5,803	Confidential
Process Fuel Share – Electricity (production of RFO)	Inputs Z613	12.7%	Confidential
Process Fuel Share – Natural Gas (production of RFO)	Inputs Z614	0%	Confidential
Process Fuel Share – Hydrogen (production of RFO)	Inputs Z615	87.3%	Confidential
Co-products in Pyrolysis and Upgrading before Generation – Fuel Gas (production of RFO)	Inputs Z622	4201	Confidential
% of Carbon Sequestered by Bio-Char	Pyrolysis B75	80%	Confidential
Energy Content (RFO)	Pyrolysis E93	17,450	Confidential
Pyrolysis and Upgrading: Non-combustion Emissions (SMR)	Pyrolysis AM208:AM212 and BC208:BC212	0.54 2.67 0.00 0.00 3383.73	Confidential
Shares of Combustion Processes for Each Stage - Natural Gas Small Industrial Boiler	Pyrolysis J112	0%	Confidential
Transportation & Distribution of Renewable Gasoline – Energy Use	Pyrolysis AK136:AK140	Linked to Renewable Gasoline T&D (columns DK and DL in T&D)	Confidential
Transportation & Distribution of Renewable	Pyrolysis AK142:AK150	Linked to Renewable Gasoline	Confidential

Gasoline – Emissions		T&D (columns DK and DL in T&D)	
Refinery Coprocessing in Conventional Refinery – Energy Use	Pyrolysis AJ136:AJ140	Default linking to Petroleum and Inputs tabs	Confidential
Refinery Coprocessing in Conventional Refinery – Emissions	Pyrolysis AJ142:AJ150	Default linking to Petroleum and Inputs tabs	Confidential
Rail Transport Distance – RFO to Refinery	T&D CA149	300	Confidential
Truck Transport Distance – RFO to Refinery	T&D CB149	50	Confidential
Select Feedstock	T2 Calculator B6	Miscanthus	Confidential
Select Fuel Pathway	T2 Calculator C6	Ethanol	Confidential
Select Tier 2 Fuels	T2 Calculator E7:F7	User-Defined Fuel Pathway	Confidential
Regional Electricity Mix for Feedstock	T2 Calculator B9	1-US Ave Mix	Confidential
Regional Electricity Mix for Fuel	T2 Calculator E9	1-US Ave Mix	Confidential
User-defined Electricity Mix	T2 Calculator R9:R17		Confidential

**Table 3: GREET Summary – RD with Bio-oil Transport via Rail**

Parameter	Sheet and Cell	Prior Value	Modified Value
Distance from mill to RFO production facility	T&D BX149	75	Confidential
Tree residue cargo capacity of HHD Truck	T&D AE7	18	Confidential
HHD Truck Energy consumption – backhaul	T&D CB165	969	Confidential
Diesel consumption for Tree Residue collection at mill, and receiving at RFO production facility	Inputs F275	118,006	Confidential
Tree Residue Shares (by dry weight)	Inputs F276	50%	Confidential
Moisture content of biomass when being transported	Inputs F465	30%	Confidential
Pyrolysis scenario selection	Inputs W607	Internal H2 from Fuel Gas/NG Reforming	Confidential
Biomass use (production of RFO)	Inputs Z610	3.19	Confidential
Energy use (production of RFO)	Inputs Z611	5,803	Confidential
Process Fuel Share – Electricity (production of RFO)	Inputs Z613	12.7%	Confidential
Process Fuel Share – Natural Gas (production of RFO)	Inputs Z614	0%	Confidential
Process Fuel Share – Hydrogen (production of RFO)	Inputs Z615	87.3%	Confidential
Co-products in Pyrolysis and Upgrading before Generation – Fuel Gas (production of RFO)	Inputs Z622	4201	Confidential
% of Carbon Sequestered by Bio-Char	Pyrolysis B75	80%	Confidential
Energy Content (RFO)	Pyrolysis E93	17,450	Confidential
Pyrolysis and Upgrading: Non-combustion Emissions (SMR)	Pyrolysis AM208:AM212 and BC208:BC212	0.54 2.67 0.00 0.00 3383.73	Confidential
Shares of Combustion Processes for Each Stage - Natural Gas Small Industrial Boiler	Pyrolysis J112	0%	Confidential
Transportation & Distribution of Renewable Diesel – Energy Use	Pyrolysis AP136:AP140	Linked to Renewable Diesel T&D (columns DI and DJ in T&D)	Confidential
Transportation & Distribution of Renewable Diesel	Pyrolysis AP142:AP150	""	Confidential

– Emissions			
Refinery Coprocessing in Conventional Refinery – Energy Use	Pyrolysis AO136:AO140	Default linking to Petroleum and Inputs tabs	Confidential
Refinery Coprocessing in Conventional Refinery – Emissions	Pyrolysis AO142:AO150	""	Confidential
Rail Transport Distance – RFO to Refinery	T&D CA149	300	Confidential
Truck Transport Distance – RFO to Refinery	T&D CB149	50	Confidential
Select Feedstock	T2 Calculator B6	Miscanthus	Confidential
Select Fuel Pathway	T2 Calculator C6	Ethanol	Confidential
Select Tier 2 Fuels	T2 Calculator E7:F7	User-Defined Fuel Pathway	Confidential
Regional Electricity Mix for Feedstock	T2 Calculator B9	1-US Ave Mix	Confidential
Regional Electricity Mix for Fuel	T2 Calculator E9	1-US Ave Mix	Confidential
User-defined Electricity Mix	T2 Calculator R9:R17		Confidential

**Table 4: GREET Summary – RD with Bio-oil Transport via Truck**

Parameter	Sheet and Cell	Prior Value	Modified Value
Distance from mill to RFO production facility	T&D BX149	75	Confidential
Tree residue cargo capacity of HHD Truck	T&D AE7	18	Confidential
HHD Truck Energy consumption – backhaul	T&D CB165	969	Confidential
Diesel consumption for Tree Residue collection at mill, and receiving at RFO production facility	Inputs F275	118,006	Confidential
Tree Residue Shares (by dry weight)	Inputs F276	50%	Confidential
Moisture content of biomass when being transported	Inputs F465	30%	Confidential
Pyrolysis scenario selection	Inputs W607	Internal H2 from Fuel Gas/NG Reforming	Confidential
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Process Fuel Share – Hydrogen (production of RFO)	Inputs Z615	87.3%	Confidential
Co-products in Pyrolysis and Upgrading before Generation – Fuel Gas (production of RFO)	Inputs Z622	4201	Confidential
% of Carbon Sequestered by Bio-Char	Pyrolysis B75	80%	Confidential
Energy Content (RFO)	Pyrolysis E93	17,450	Confidential
Pyrolysis and Upgrading: Non-combustion Emissions (SMR)	Pyrolysis AM208:AM212 and BC208:BC212	0.54 2.67 0.00 0.00 3383.73	Confidential
Shares of Combustion Processes for Each Stage - Natural Gas Small Industrial Boiler	Pyrolysis J112	0%	Confidential
Transportation & Distribution of Renewable Diesel – Energy Use	Pyrolysis AP136:AP140	Linked to Renewable Diesel T&D (columns DI and DJ in T&D)	Confidential
Transportation & Distribution of Renewable Diesel	Pyrolysis AP142:AP150	""	Confidential

– Emissions			
Refinery Coprocessing in Conventional Refinery – Energy Use	Pyrolysis AO136:AO140	Default linking to Petroleum and Inputs tabs	Confidential
Refinery Coprocessing in Conventional Refinery – Emissions	Pyrolysis AO142:AO150	""	Confidential
Rail Transport Distance – RFO to Refinery	T&D CA149	300	Confidential
Truck Transport Distance – RFO to Refinery	T&D CB149	50	Confidential
Select Feedstock	T2 Calculator B6	Miscanthus	Confidential
Select Fuel Pathway	T2 Calculator C6	Ethanol	Confidential
Select Tier 2 Fuels	T2 Calculator E7:F7	User-Defined Fuel Pathway	Confidential
Regional Electricity Mix for Feedstock	T2 Calculator B9	1-US Ave Mix	Confidential
Regional Electricity Mix for Fuel	T2 Calculator E9	1-US Ave Mix	Confidential
User-defined Electricity Mix	T2 Calculator R9:R17		Confidential